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words and not by a profounder analysis. How, pray, can we think of substance as the possessor of aspects? But the motives that led to this theory must give it precedence to materialism.

With the results of this study as a basis, we shall at last be able to examine thoroughly the problem of ontological causation with the question of the efficiency of this variant, consciousness, as an illuminating point of departure.[3]

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THE PERCEPTUAL BASIS FOR JUDGMENTS OF EXTENT

IN 1887, in the course of experiments on the extent of movement, Loeb[1] was led to the supposition that the judgment of extent is based on the perception of the duration of the movement. Since then Kramer and Moskiewicz,[2] in 1901, and Jaensch,[3] in 1905, have felt that their experimental results led to the same conclusion. Woodworth,[4] in 1903, discredits the hypothesis. His chief objections are: (1) Duration may be varied without entirely destroying the approximate equality of the extents; (2) extent can be judged better than time; (3) compensatory constant errors with higher speed are insufficient; (4) if we judged by duration alone, speed distinctions would be reduced to a matter of visual space or perception of force.

In June, 1909, the writer published, along with other matter,[5] the result of a long series of experiments on the relation between the judgments of extent and duration in the case of rectilinear arm movements. His conclusion there was that "the experimental facts point to separate processes of judgment for the two magnitudes, extent and duration. The four methods of separate accuracy tests, confusion, correlation, and correction failed to justify the assumption that the perception of any one characteristic of a movement is more primitive or fundamental than that of any other. The judgment of extent seems to be based on a system of signs which have been learned to mean extent directly. The same seems to be true of both duration and velocity."[6]

In the July (1909) number of the *American Journal of Psychol-*

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[3] See, however, an article on causality, this JOURNAL, Vol. VI., pp. 323-328.

[1] *Pflüger's Archiv*, 41, p. 124, 1887.

[2] *Zeitschrift für Psychologie*, 25, pp. 101-125, 1901.

[3] *Ibid.*, 41, pp. 257-279, 1905.

[4] "Le Mouvement," Chap. IV.

[5] "The Inaccuracy of Movement," H. L. Hollingworth, *Archives of Psychology*, No. 13, 1909.

[6] *Ibid.*, pp. 85-86.

ogy, Professor Leuba[7] reported experiments, on the results of which he arrives at conclusions quite opposed to those quoted in the preceding paragraph. "The comparison of the length of arm movements is made through the comparison of the duration of one or several of the sensations arising from the movement and of a particular value of the joint sensation called here the rate value."

In the face of such conflicting opinion the writer desires to present in abbreviated form the results of his experiments and to give certain additional reasons in support of his earlier conclusions.[8] From 600 to 800 experiments were performed on each of four subjects, by the method of average error, on extents ranging from 150 to 650 mm. and on corresponding durations ranging from 1 to 3.5 seconds. By using a piece of apparatus already described elsewhere,[9] all the movements, while they remained active, were free from the *illusion of impact* which has vitiated so much of the work on movement. The apparatus gave simultaneous graphic records of the extent, duration, speed, and energy of every movement performed. For further details of the experiment and for a more complete presentation of most of the data used in the present article the reader must be referred to the writer's earlier monograph. The following table gives the C.E. and V.E. for the extents and their corresponding durations, when the observer tries to reproduce (1) the extent and (2) the duration of his first movement. In still

TABLE SHOWING RELATION BETWEEN ERRORS OF EXTENT AND ERRORS OF DURATION

	EXTENT					DURATION				
Obs.	Trials	Per Cent. C.E.	Per Cent. V.E.	Per Cent. Right Guesses	r	Trials	Per Cent. C.E.	Per Cent. V.E.	Per Cent. Right Guesses	r
				Deliberate						
W.	450	6±2.0	13±0.6	59	.22	375	5±1.3	11±0.7	46	.31
H.	450	19±1.7	12±0.6	54	.56	375	16±2.0	12±0.9	52	.54
Bt.	287	24±3.8	18±1.5	64	.79	264	20±3.5	16±1.2	61	.67
L.	375	7±0.8	7±0.6	60	.54					
Averages		14±2.1	12.5±0.8	59	.53		13.7±2.3	13±0.9	53	.51
				Incidental						
W.	375	8±1.7	13±0.8	49		450	10±1.8	20±0.9	53	
H.	375	9±1.3	12±0.6	56		450	8±0.9	12±0.6	58	
Bt.	264	15±2.2	15±1.2	65		287	17±2.8	20±1.3	63	
L.						375	5±1.5	13±0.9	56	
Averages		10.7±1.7	13.3±0.9	57			10±1.7	16.3±0.9	56	

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[7] *American Journal of Psychology,* July, 1909, p. 374.

[8] Professor Leuba's article was probably in the hands of the printer when "The Inaccuracy of Movement" appeared.

[9] H. L. Hollingworth, *op. cit.,* Chap. I.

other columns may be found the per cent. of right guesses when the observer guessed, after each trial, as to the probable direction of his error, and the coefficient of correlation between agreement of extents and agreement of durations calculated by the method of unlike signs. On the basis of these figures the writer draws the following conclusions.

1. The durations of extents intended to be equal have greater V.E. (16.3 per cent.) than the extents themselves (12.5 per cent.). There must be, then, some basis for the judgment of extent other than the perception of duration.

2. The C.E. seems to be bound up with the process of attention, the magnitude deliberately reproduced [extent (14 per cent.) or time (13.7 per cent.)] being greater than that of the magnitude incidentally reproduced [time (10 per cent.) or extent (10.7 per cent.)]. This evident separation between the magnitude attended to and that incidentally executed argues for separate processes of judgment for the two magnitudes, extent and duration.

3. If the perception of duration were the basis of the judgment of extent, incidentally reproduced durations should show as close correspondence as durations deliberately reproduced. This is not the case.

4. Extents agree as closely when the observers are reproducing duration (V.E. 13.3 per cent.) as when they are attending to the extent (V.E. 12.5 per cent.), but durations incidentally executed do not correspond as closely (V.E. 16.3 per cent.) as in deliberate experiments on reproduction of duration (V.E. 13 per cent.). That is to say, if either judgment is to be considered the more primitive and fundamental it is the judgment of extent rather than that of duration.

5. The coefficients of correlation between deliberate extents and incidental durations (+ .53) on the one hand, and between deliberate durations and incidental extents (+ .51) on the other, are positive. But all that this shows is the presence of positive correlation between extent and duration, no matter which factor is being attended to. There is as much evidence for the dependence of duration judgments on the perception of extent as for the converse.

6. If the observer is required to guess as to the probable direction of his error in the case of each attempt to reproduce either extent or duration, (*a*) the guesses in both cases correspond more closely to the actual errors of the extents (59 per cent., 57 per cent.) than to the differences between the durations (57.5 per cent., 53 per cent.); (*b*) the proportion of right guesses in experiments on extent (59 per cent.) is greater than that in experiments on duration (53 per cent.). These facts are unfavorable to the hypothesis that it is the perception of duration on which the judgment of extent is based.

Professor Leuba's chief argument is based on the proposition that the durations of movements judged shorter, equal, or longer than a standard fall out shorter, equal, or longer as compared with the duration of the standard. Unfortunately, neither the variability nor the reliability of the average is given, nor is the number of cases, from which a reader might compute the reliability himself. But even if the correspondence were found to be *complete* such statistical correspondence would throw no light whatever on the nature of the process of discrimination involved in the comparison of the two lengths. If Professor Leuba had kept accurate measurements of the depth of the wrinkles in the loose glove which covered the arm of the observer he would have found the same positive correlation—when the extents were judged shorter the wrinkles would have been found to be relatively shallow, and they would have been equal or deeper according as the judgment happened to be "same" or "longer."

It is a case in which denying one member of the disjunction disproves a conclusion which is not proved by the affirmation of the other member. In other words, even though the relations of the durations do coincide with the form of the judgment, this duration agreement may still be simply an incidental fact, on a par with the depth of the wrinkles in the observer's sleeve. With the rather constant speed characteristic of all observers in such experiments a greater extent must occupy a longer duration, an equal extent an equal duration, etc. To show that the durations *do not* agree as closely as the extents, as the writer has already done,[10] invalidates Professor Leuba's conclusion, while to prove that they agreed equally well would have no bearing whatever on the question of the perceptual basis of the judgment of comparison.

The movements reported in Professor Leuba's article were made in different parts of the arm's total swing, under different degrees of contraction, tension, joint position, etc. The only common factor was the time element. Now even to prove that under these unusual conditions the duration of movements is used as the basis for the comparison of their extent does not prove that this is what happens in other cases. But to show that even here the durations disagree more than the extents disproves the hypothesis completely.

With Professor Leuba's assertion of a special set of signs which serve as criteria for judgments of speed, the writer heartily agrees.[11] but he is convinced that along with this assertion should also go the recognition of the independent character of judgments of extent and duration as well.

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[10] "The Inaccuracy of Movement," Chap. IV., p. 40.

[11] *Ibid.*, pp. 61-62.